FWS National Wildlife Refuge System Wilderness Fellows

Report on Wilderness Character Monitoring

Agassiz Wilderness

Agassiz National Wildlife Refuge

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September 2011

Whiskey Lake Peatland

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INTRODUCTION TO THE PROJECT

This report provides a detailed summary of the baseline wilderness assessment completed for the Agassiz Wilderness on the Agassiz National Wildlife Refuge (NWR), located in northwestern Minnesota. The Wilderness Character Monitoring framework applied throughout this process was developed by an interagency wilderness team and is described in the Forest Service publication, *Keeping It Wild: an interagency strategy to monitor trends in wilderness character across the National Wilderness Preservation System* (Landres et al. 2008). The framework initiates a methodology for quantifying aspects of wilderness for long-term monitoring.

Many unique measures of wilderness character were created that are specifically relevant to the Agassiz Wilderness. However, every indicator within the framework must be represented by at least one measure, whether it is pertinent to a particular wilderness or not. The purpose of this is to ensure a comprehensive and consistent representation of Wilderness status throughout U.S. Fish and Wildlife Service National Wildlife Refuge system lands.

The purpose of this report is multi-dimensional. It establishes a wilderness character monitoring program for the Agassiz Wilderness and provides baseline data for future trend analysis. An understanding of the information in this report may also aid resource specialists by informing management decisions within the Agassiz Wilderness. Finally, this report is meant to accompany and explain the results of Agassiz's wilderness character assessment that have been entered into a national wilderness character monitoring database.

SETTING OF THE REFUGE WILDERNESS

HISTORY OF WILDERNESS ESTABLISHMENT

Agassiz NWR was originally established as Mud Lake Refuge by Executive Order No. 7583, dated March 23 1937, to serve principally as a waterfowl production and migration area. The original parcel of land established as Wildlife Refuge totaled 60,215 acres. The Refuge was re-named in 1961 after Glacial Lake Agassiz, an ancient body of water that had once blanketed the entire area. In 1964, an additional 1,272 acres were acquired, bringing Agassiz to its present size of 61,487 acres.

The Agassiz Wilderness Study Area was designated in accordance with The Wilderness Act of September 3, 1964 (Public Law 88-577), which required that every roadless area within the National Wildlife Refuge System of 5,000 acres or more be set aside for study to determine its suitability as a wilderness. The study area included a portion of the Refuge dominated by black spruce-tamarack swamp, representing the most westerly extension of this community type in Minnesota. One of the principal objectives established in the original Master Plan for Agassiz was to maintain this segment of undisturbed bog habitat. Within the Refuge's history, no active form of management had been practiced, and, except for vegetative succession, the area appeared essentially the same as when the Refuge was established. Although only 4,000 acres in size, the Agassiz Wilderness was designated within the National Wilderness Preservation System by the 94th Congress, with the passage of Public Law 94-557 on October 19, 1976.

GEOGRAPHIC SETTING

Agassiz NWR is located in eastern Marshall County, in the extreme northwestern portion of Minnesota. Located only 40 miles south of the U.S. border with the Canadian province of Manitoba, the 61,500-acre

Refuge is surrounded by 22,838 acres of state-owned, protected lands; namely Elm Lake, Eckvoll, Whitford, and Mud Lac Wildlife Management Areas. The towns of Goodridge, Grygla, Holt, Middle River, Newfolden, and Thief River Falls are all within 30 miles of the Refuge headquarters. The only one of these with a population of over 1,000 people is Thief River Falls (approximately 8,500 residents). The closest city with a population of over 25,000 is Grand Forks, ND, located 75 miles to the southwest of the Refuge. Agassiz's wilderness is comprised of 4,000 acres of black spruce-tamarack swamp, peatland, and poor fen plant communities in the north-central part of the Refuge.

ECOLOGICAL SETTING

As the last Ice Age receded approximately 10,000 years ago, melt water poured from a glacier that spanned an area greater than that of the present-day five Great Lakes. This formed an enormous inland sea that was later named Glacial Lake Agassiz, in honor of the Swiss-American naturalist Jean Louis Rodolphe Agassiz. This ancient body of water produced many geological attributes that characterize the area still today. For this reason, Agassiz NWR is typified by exceedingly flat terrain (with a gradient averaging 1.5 feet per mile from east to west across the Refuge) and soils that are mainly peat and silty loams underlain by clayey glacial drifts.

The climate in northwestern Minnesota is characterized by long cold winters and relatively short, warm summers. January is the coldest month with average maximum and minimum temperatures of 13 and -8 degrees F, respectively. These contrast with respective means of 80 and 55 degrees F in July, the warmest month. Winter is relatively dry while summer is the wettest season, making thunderstorms the main source of rain in the area. Precipitation averages 21 inches annually with most of this occurring between April and September. Approximately 39 inches of snowfall occur annually and frequent northwest winds in this flat terrain cause drifting and extreme wind chills. The average frost-free period is 115 days. The major threat of flooding at Agassiz NWR is the result of spring runoff of snowmelt following wet winters. Flooding is one of the key issues affecting the Refuge – both its habitat and its facilities – as well as the neighboring region.

As a former embayment in the bed of Glacial Lake Agassiz, the Refuge is also situated in a narrow transitional zone known as aspen parkland, within the Mississippi Headwaters/Tallgrass Prairie Ecosystem as defined by the U.S. Fish and Wildlife Service. This ecosystem is primarily located in Minnesota and North Dakota with small portions extending into Wisconsin and Iowa. The aspen parkland ecotone represents the convergence of coniferous forest to the east, boreal forest to the north, and the tallgrass prairie and prairie pothole regions to the west and south. Of these major ecological communities, the tallgrass prairie (which includes oak savanna and barrens) is by far the most threatened, with more than 99% having been converted to agricultural uses.

Vegetation at the turn of the century was primarily prairie and open marshes with scattered clones of aspen. Around this time, however, settlers were lured by farming promoters into what was then a boggy wilderness, hoping to convert it to farmland. In an effort to make farming more feasible and productive, the federal government backed loans to state, local, and private interests that undertook an expensive drainage project in 1909. This drainage system eventually became one of the largest public drainage projects ever developed in the United States. A million dollars were spent on the drainage system without the anticipated farming success. High tax assessments on drainage costs were a major financial burden on affected landowners, and ultimately the financial condition of Marshall County. To rescue the county from bankruptcy, the Minnesota Legislature passed a statute to absorb the drainage taxes and authorized the lands to be purchased by the federal government for the development of the Mud Lake

Migratory Waterfowl Refuge, established by Franklin D. Roosevelt in 1937.

Once established as a unit of the National Wildlife Refuge System, active habitat management was undertaken by Refuge staff. Wetlands were restored by constructing an extensive system of dikes, spillways, and water control structures. The Refuge includes 26 man-made water impoundments (known as pools) that range in size from 30 to 10,000 acres. Today, water levels and flows are manipulated to create a variety of wetland types with a mix of emergent and submergent vegetation communities. The Refuge's dominant geographic features are its impoundments and associated marshes, mudflats, and open water. They also aid in the Refuge's habitat management efforts on behalf of waterfowl, migratory birds, and other water-dependent bird species. In addition, prescribed fire and mowing are widely employed to manage habitats such as grasslands, shrublands, and sedge meadows to benefit nesting waterfowl, deer, moose, songbirds, and other native wildlife. In the past, farming was used to attract migrating waterfowl and to benefit resident wildlife. A variety of small grains were planted including barley, oats, and wheat. Presently, the Refuge is undertaking an initiative to convert all of these farm units into native grass.

The area as a whole, presents a mosaic of several different vegetation types. Over one-half (37,400 acres) of the Refuge is presently marsh, other wetlands, and open water less than five feet deep. The Refuge also includes approximately 11,650 acres of shrubland; 9,900 acres of woodland; 1,710 acres of grassland; and 170 acres of cropland. Specific cover types include willow, deciduous hardwoods, conifers and open fields in various stages of succession. Extensive land clearing and drainage surrounding the Refuge and adjacent state wildlife management areas has radically altered the original landscape.

Despite this fact, the diversity of habitats supports a wide array of resident and migratory wildlife, including 300 species of birds, 49 species of mammals, 12 species of amphibians, and nine species of reptiles. The Refuge's 61,500 acres are a key breeding ground for 17 species of ducks and the Refuge is an important migratory rest stop for waterfowl. The Refuge is also noted for its two resident packs of gray wolves, moose, black bear, and nesting bald eagles.

The Agassiz Wilderness appears as a large peninsula of bog habitat lying between three major impoundments in the north central portion of the Refuge; namely Agassiz Pool, Thief Bay Pool, and Webster Pool. It is approximately 3.5 miles long on its north-south axis and 2.5 miles across at its widest point. The area is divided into North and South units by an east-west corridor (dike) bordered on either side by drainage ditches. This trail is passable only during dry periods and serves as the access point for nearly all foot traffic into the area. This 200-foot corridor is excluded from wilderness designation and will be referred to as "the Wilderness Dike" in subsequent sections of this report.

The North unit comprises approximately 2/3 of the wilderness. The major cover type in this 2,500-acre unit is black spruce and tamarack swamp, which, as mentioned previously, is one of the most westerly extensions of this forest type in Minnesota. Mixed aspen and willow surround the spruce and tamarack forest, while narrow bands of cattail and phragmites separate these woodlands from the open water of Thief Bay and Webster Pools. The South unit of the wilderness is bordered on three sides by Agassiz Pool, the largest wetland unit on the Refuge. The major plant community in this 1,500-acre unit is aspen. Whiskey and Kuriko Lakes, which are two of the Refuge's three natural lakes, are located within the wilderness as well. Whiskey Lake is 20 acres in size and located in the south-central portion of the North unit, whereas the 40-acre Kuriko Lake is located in the central portion of the South unit. Soils in the wilderness area can be characterized mainly as poor fen peatlands covered in sphagnum moss.

REGUGE PURPOSES

Agassiz NWR was originally established as a "refuge and breeding ground for migratory birds and other wildlife" (Executive Order 7583). Under the Migratory Bird Conservation Act, it was also promised "for use as an inviolate sanctuary, or for any other management purpose, for migratory birds". In this capacity, Agassiz NWR serves a dual purpose both as a critical nesting ground and as an important link in the Mississippi Flyway network of Refuges that serve as rest stops and feeding stations for migrating ducks and geese. Lastly, under the National Wildlife Refuge System Administration Act, every Refuge was purposed for the "conservation, management, and restoration of the fish, wildlife, and plant resources and their habitats for the benefit of present and future generations of Americans".

As a result of the 1985 Food Security Act, Agassiz NWR assumed additional responsibilities for a seven-county Refuge Management District (RMD). Staff duties expanded to include working with the National Resources Conservation Service (NRCS) and Farm Service Agency (FSA) on wetland determinations, Swampbuster Act provisions, and the Conservation Reserve Program (CRP). Refuge objectives expanded to include actively collaborating on habitat restoration projects for both uplands and wetlands on private and CRP lands throughout its RMD.

According to the Refuge's Wilderness Management Plan (1981), "the primary objective at Agassiz NWR is to manage wetland and upland habitats so as to provide for as near optimum conditions for waterfowl and other wildlife species as is feasible." Although the original focus at Agassiz NWR was on waterfowl, over the years other migratory birds and resident wildlife species have received an increasing emphasis in Refuge management. The Vision Statement from the current Comprehensive Conservation Plan (2005) states that Agassiz's management will be aimed towards: working with partners to take a landscape approach for the promotion of functional watersheds and natural areas, emulating the natural functions of different native habitats for optimal wildlife use, and showcasing the compatibility of biological diversity and ecological integrity with sustainable agriculture.

STAFF CONSULTED

The following is a listing of the names and titles of Agassiz NWR staff members consulted in this process:

Maggie Anderson, Refuge Manager
Gregg Knutsen, Refuge Biologist
Larry Anderson, Fire Management Officer
Ashley Hitt, Biological Technician

PROCESS USED FOR IDENTIFYING MEASURES

Wilderness Character Monitoring requires the identification of quantifiable measures that reflect wilderness character. Changes in the values of these measures over time will be used as an index to evaluate trends in the four primary wilderness qualities: Untrammeled, Natural, Undeveloped, and Opportunities for Solitude/Primitive and Unconfined Recreation. The changes in the values of these measures are supposed to correlate with improvements or degradations of wilderness character.

In order to identify a suite of relevant and feasible wilderness character monitoring measures for the Agassiz Wilderness, I began by learning as much as possible about the wilderness. I reviewed many

documents discussing Agassiz NWR and the Agassiz Wilderness specifically, relating to its history, management, past and possible sources of degradation, and relevant ecological research. The purpose of this process was not only to learn about the wilderness, but also to start accumulating knowledge of available data and data sources.

During this time, I attended a Refuge staff meeting to explain the process and objectives of my project. I also had individual meetings with Maggie Anderson (Refuge Manager) and Gregg Knutsen (Refuge Biologist) to discuss my project in more detail. I was also fortunate enough to accompany Biological Technician Ashley Hitt on several trips to the wilderness for various field projects. These projects included vegetation sampling, invasive species inventory, and the release of biological control agents for Canada thistle. Additionally, I spent several hours in the wilderness with Kyle Johnson, University of Wisconsin graduate student, learning about his research on lepidopterans and helping him set up a study sight. These expeditions into the wilderness allowed me to familiarize myself with its community types, personally observe its pristine nature, and gain a sense of potential wilderness character issues.

With reasonable knowledge of the Agassiz Wilderness and the available data, I began developing a rough draft of possible measures. I used the measures from *Keeping It Wild* as a guideline in order to ensure that I was capturing as many characteristics of wilderness as possible. I expanded upon these measures in order to incorporate issues of specific relevance or concern to the Agassiz Wilderness. This first draft of measures was submitted to both Maggie Anderson and Gregg Knutsen for review. I held a meeting with both individuals to discuss their comments and ensure my understanding of their suggestions.

I then edited the first draft of measures and incorporated Refuge staff suggestions. I also reworded, disposed of, or changed measures based on their relevance to the Agassiz Wilderness and further knowledge of the scope of available data. I then completed prioritization exercises for every potential measure, allowing me to rank them based on their importance, vulnerability, reliability, and reasonableness. This process allowed me to edit the set of measures again; focusing, simplifying, and prioritizing specific attributes. The list of measures resulting from this exercise was again submitted for approval by Gregg Knutsen. Once the measures were finalized, I entered them into the national wilderness character monitoring database and began collecting data.

MEASURES USED

UNTRAMMELED QUALITY

The document *Keeping It Wild* states the following regarding the untrammeled quality: The Wilderness Act states that wilderness is “an area where the earth and its community of life are untrammeled by man,” and that “generally appears to have been affected primarily by the forces of nature.” In short, wilderness is essentially unhindered and free from modern human control or manipulation. This quality is degraded by modern human activities or actions that control or manipulate the components or processes of ecological systems inside the wilderness.

Monitoring question: What are the trends in actions that control or manipulate the "earth and its community of life" inside wilderness?

Indicator: Actions authorized by the Federal land manager that manipulate the biophysical environment

Measure 1: Number of actions taken to manage plants

Description: Monitored annually. This measure is a count of the number of actions taken to manage any plant species or vegetative community inside wilderness. The count should include all management activities involving the following: biological, chemical, or mechanical control of invasive species; the authorization of research or monitoring activities that involve significant disruption of vegetation; seeding; planting; fertilizing; restoration activities, etc. Significant disruption to vegetation includes, but is not limited to, actions such as: large-scale plant harvesting, cutting, damaging, or trampling. In general, the untrammeled quality would be degraded if the number of actions increases.

An "action" should be determined according to the guidelines set forth on page 55 of the Forest Service *Technical Guide for Monitoring Selected Conditions Related to Wilderness Character*. The guidelines are as follows:

A single action occurring at a single location = 1 action
A single action occurring at multiple locations= 1 action
Multiple actions occurring at a single location= multiple actions
Multiple actions occurring at multiple locations= multiple actions
An action occurring within in a single fiscal year= 1 action
An action spans multiple fiscal years without interruption= 1 action
An action spans multiple fiscal years with interruption= multiple actions

Context: The Agassiz Wilderness is home to many unique, native plant species. However, it is also at risk of invasive species disturbance, as certain indigenous and non-indigenous species populations are increasing on the dike that cuts through the wilderness. Certain research and control projects are necessary in order to identify or monitor native species, while ensuring that invasive species populations do not become unmanageable. While these projects are often initiated with the intent of improving the natural character of wilderness, they must be monitored for the intensity or frequency of their effects on wilderness. For instance, research conducted by Rhett Johnson (University of Minnesota- Duluth graduate student) identified the reason behind black spruce and tamarack die-off on the western edge of the wilderness and determined appropriate water levels for surrounding impoundments that would alleviate this problem. However, his work involved the installment of 99 water level observation wells, the coring of trees, and the clearing of lanes along transect lines. Additionally, past invasive species management has been constrained to the Wilderness Dike, which was spot-sprayed for reed canary grass in 2009 and 2010. This past summer, however, it was noted that populations of Canada thistle were exploding on the dike (outside wilderness designation) and stands of reed canary grass were identified within official wilderness boundaries. In order to address this problem before it became more widespread, Canada thistle weevils were released on the dike in August 2011 and chemical herbicide

(glyphosate) was hand applied to areas of reed canary grass inside the wilderness during September 2011.

Relevance to the indicator: Wilderness, by definition, is land where ecological functions have been allowed to operate without human manipulation. It is a place where natural conditions prevail and we, as humans, must accept the results with interest and humility. There are certainly valid reasons behind many monitoring, research, management, or restoration projects. However, the purposeful manipulation of individual plant species or plant communities by federal land managers inside wilderness disturbs its unadulterated state. The purpose, frequency, and intensity of each of these projects must be considered carefully in regard to its effect on wilderness character and this warrants monitoring.

Data source: Annual narratives, minimum requirement analyses, Rhett Johnson's thesis (Peatland Trees and Hydrology: A Dendrochronological Examination of Black Spruce and Tamarack Growth and Associated Hydrology in a Peatland in Marshall County, Minnesota).

Process used to compile or gather the data: Review of the documents listed above.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

Measure 2: Number of actions taken to manage animals

Description: Monitored annually. This measure is a count of the number of actions taken to manage any individual animal and/or animal population inside wilderness. The count should include all management activities involving the following: reintroduction, introduction, supplementation of wildlife species; removal of animals through management-recommended hunting regulations or predator control programs; authorization of research or monitoring activities that involve significant disruption of animals; manipulation of habitat for wildlife; insect or disease control. Significant disruption to animals includes, but is not limited to, actions such as: capturing, collaring, implanting transmitters, collecting blood/tissue samples, electro-shocking, sterilizing, etc. An "action" should be determined according to the guidelines set forth on page 55 of the Forest Service *Technical Guide for Monitoring Selected Conditions Related to Wilderness Character*. See Measure 1 for details regarding the tallying of actions. In general, the untrammeled quality would be degraded if the number of actions increases.

Context: The wild and pristine nature of the Agassiz Wilderness allows it to provide habitat to a diversity of wildlife. Monitoring and management of these species is sometimes necessary for population or community health. Likewise, research can provide important knowledge regarding the status or presence of rare or declining species. While these projects are often initiated with the intent of improving the natural character of wilderness, they must be monitored for the intensity or frequency of their effects on wilderness. For example, Kyle Johnson’s research provided a plethora of data on the wilderness area's lepidopteran species, but involved using a motorized generator and a floodlight, as well as the capture of a great number of moths and other insects. Additionally, although hunting limits and regulations are decided upon at a State level, recommendations are made by Refuge staff based on local population levels. These recommendations (whether or not they evolve into official regulations for the season) should be counted as manipulations in this category if they are made with the express purpose of decreasing animal populations to meet objective density levels. Very little animal research or

management currently occurs within the Agassiz Wilderness, and data for 2011 shows 0 actions were taken.

Relevance to the indicator: Wilderness, by definition, is land where ecological functions have been allowed to operate without human manipulation. It is a place where natural conditions prevail and we, as humans, must accept the results with interest and humility. There are certainly valid reasons behind many monitoring, research, or management projects. However, the purposeful manipulation of animal species or populations by federal land managers inside wilderness disturbs its unadulterated state. The purpose, frequency, and intensity of each of these projects must be considered carefully in regard to its effect on wilderness character and this warrants monitoring.

Data source: Annual narratives, minimum requirement analyses, Kyle Johnson (University of Wisconsin researcher on a lepidopteran study inside wilderness).

Process used to compile or gather the data: Review of documents listed above and personal communication with Kyle Johnson.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

Measure 3: Number of actions taken to manage water

Description: Monitored annually. This measure is a count of the number of actions taken to manage natural hydrology or water chemistry or to alter watercourses or develop water control structures. This measure should include all management activities involving the following: setting water level objectives that deviate from recommendations for wilderness-adjacent pools (maximum of 348.80 m and 348.60 m above sea level for Thief Bay and Webster Pools, respectively); water structure development; soil addition and/or removal for water control purposes etc. An "action" should be determined according to the guidelines set forth on page 55 of the Forest Service *Technical Guide for Monitoring Selected Conditions Related to Wilderness Character*. See Measure 1 for details regarding the tallying of actions. In general, the untrammeled quality would be degraded if the number of actions increases.

Context: The natural hydrology of the Agassiz Wilderness was already altered at the time of its designation from years of drainage projects in the area. There is a dike bordered by drainage ditches on either side that cuts the wilderness in half and is officially exempt from wilderness designation. Future restoration efforts on this disturbed area would be counted under this measure, but should be noted for their profound positive impacts on the natural quality of wilderness. The wilderness is also surrounded on three sides by artificial water impoundments. High levels in these pools had caused extensive black spruce and tamarack mortality on the west side of the wilderness in the late 1990s. Water levels in these impoundments are now managed carefully to avoid this problem. Further alterations to wilderness hydrology are unlikely, but if there becomes a potential for such a project it should be considered carefully due to its degradation of wilderness character.

Relevance to the indicator: Wilderness, by definition, is land where ecological functions have been allowed to operate without human manipulation. It is a place where natural conditions prevail and we, as humans, must accept the results with interest and humility. There are certainly valid reasons behind many monitoring, research, management, or restoration projects. However, the purposeful

manipulation of watercourses, soil structure, or chemical composition by federal land managers inside wilderness disturbs its unadulterated state. The purpose, frequency, and intensity of each of these projects must be considered carefully in regard to its effect on wilderness character and this warrants monitoring.

Data source: Water Management Records (2006-2011), Annual Water Management Plans.

Process used to compile or gather the data: Review of the documents listed above.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

Measure 4: Number of actions taken to manage fire

Description: Monitored annually. This measure is a count of the number of actions taken to influence the natural fire regime or fuel loads inside wilderness. This measure should include all management activities that involve the following: fire ignitions, prescribed burns, natural fire suppression responses, fuel load reduction activities, etc. An "action" should be determined according to the guidelines set forth on page 55 of the Forest Service *Technical Guide for Monitoring Selected Conditions Related to Wilderness Character*. See Measure 1 for details regarding the tallying of actions. In general, the untrammeled quality would be degraded if the number of actions increases.

Context: It is estimated that the conifer swamp had a historic catastrophic fire rotation of 570 years and surface fire rotation of 90 years. Agassiz's Fire Management Plan (2008) places both the North and South wilderness units under the Old Growth Prescription, stating that no cutting or mowing will be done and burns may be considered on a 50+ year interval. Past fire suppression activities and natural succession have resulted in the late-stage black spruce-tamarack forest that the wilderness was designated for, along with high fuel loads. Prescribed fire in the wilderness is therefore risky and is not being considered as a management tool in wilderness at the present time.

Relevance to the indicator: Wilderness, by definition, is land where ecological functions have been allowed to operate without human manipulation. It is a place where natural conditions prevail and we, as humans, must accept the results with interest and humility. There are certainly valid reasons behind many fire management or fire regime restoration projects. However, the purposeful manipulation of natural fire disturbance regimes by federal land managers inside wilderness disturbs its unadulterated state. Such projects must be considered carefully in regard to their effect on wilderness character and this warrants monitoring.

Data source: Habitat Management Plan, Wilderness Management Plan, Fire Management Plan, Wildland Fire Management Plan, professional judgment of Fire Management staff.

Process used to compile or gather the data: Review of the documents listed above and personal communications with Fire Management staff.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

Indicator: Actions **not** authorized by the Federal land manager that manipulate the biophysical environment

Measure 5: Number of unauthorized actions taken by agencies, citizen groups, or individuals that influence the community of life inside wilderness

Description: Monitored annually. This measure is a count of the number of unauthorized or illegal actions taken that manipulate plants, animals, water, soil, or fire inside wilderness. This measure should include all activities not authorized by the federal land manager that influence the natural environment of the wilderness. Examples of such actions include poaching; fishing; seed, plant, or animal harvesting; planting, etc. An "action" should be determined according to the guidelines set forth on page 55 of the Forest Service *Technical Guide for Monitoring Selected Conditions Related to Wilderness Character*. See Measure 1 for details regarding the tallying of actions. In general, the untrammeled quality would be degraded if the number of actions increases.

Context: According to Refuge staff, there are currently no unauthorized actions taking place inside the Agassiz Wilderness that could potentially influence the natural community of life. Such activities have never been an issue at Agassiz in the past and are not predicted to be an issue in the foreseeable future. This measure was included for the purpose of representing this indicator within the wilderness character monitoring framework.

Relevance to the indicator: Wilderness, by definition, is land where ecological functions have been allowed to operate without human manipulation. It is a place where natural conditions prevail and we, as humans, must accept the results with interest and humility. Unauthorized or illegal activities by outside parties can alter natural communities and trammel wilderness. These actions disturb the unadulterated state of wilderness and degrade wilderness character. While the federal land manager often has little control over such actions, the unauthorized manipulation of wilderness populations or communities must be taken very seriously and necessitates monitoring.

Data source: Annual narratives, professional judgment of Refuge staff.

Process used to compile or gather the data: Review of the documents listed above and personal communication with Refuge staff.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

NATURAL QUALITY

The document *Keeping It Wild* states the following regarding the natural quality: The Wilderness Act states that wilderness is “protected and managed so as to preserve its natural conditions.” In short, wilderness ecological systems are substantially free from the effects of modern civilization. This quality is degraded by intended or unintended effects of modern people on the ecological systems inside the wilderness since the area was designated.

Monitoring question: What are the trends in terrestrial, aquatic, and atmospheric natural resources inside wilderness?

Indicator: Plant and animal species and communities

Measure 6: Percent of wilderness dominated by indigenous and/or non-indigenous invasive plant species

Description: Monitored every 5 years. This measure is meant to track the spread of invasive plants inside wilderness. According to current plans, this will be measured using remotely sensed data and spectral analysis. A unique spectral "signature" will hopefully be differentiable for key invasive species, thus making areas where invasive plant species dominate the vegetation cover visible. These areas will be measured, summed, and then divided by the area of the entire wilderness in order to attain a percentage value. In general, the natural quality would be degraded if the percentage of wilderness dominated by invasive species increases.

Context: The Refuge at large has significant populations of invasive cattail, Phragmites, reed canary grass, and Canada thistle. These plant species, however, have only recently begun to invade the wilderness. Reed canary grass was sprayed on the Wilderness Dike (which is exempt from wilderness designation) in the fall of 2009 and 2010 with positive results. Minimal reed canary grass remained on this dike after two years of chemical treatment. However, in portions of the dike where reed canary grass was eliminated, extensive amounts of Canada thistle became established. To address the increase in Canada thistle, Refuge staff released Canada thistle weevils in three different locations on the dike in August 2011. Reed canary grass has also recently been documented in areas within official wilderness designation. In order to ameliorate this situation and prevent further proliferation of the species, Refuge staff decided to have a Minnesota Conservation Corps crew manually apply herbicide to reed canary grass inside the wilderness. This was completed in September of 2011. Official data for this measure relies on the results of work being done by a remote sensing expert at Bemidji State University, who is analyzing satellite images of Agassiz NWR. This project was in progress prior to the initiation of wilderness character monitoring. Data for this measure is not yet available as of 10/2/2011.

Relevance to the indicator: The Agassiz Wilderness is home to many unique and/or rare native plant species. However, it is also at risk of invasive species disturbance, as certain indigenous and non-indigenous invasive species populations are increasing on the Wilderness Dike. The location of these species unfortunately provides them with easy access into the wilderness, and this spread has already begun. The proliferation of invasive species inside the wilderness threatens to diminish or extinguish populations of native plant species and communities. It is essential to monitor the status of native species while tracking the location and movement of invasive species.

Data source: Unpublished Refuge data.

Process used to compile or gather the data: N/A

Significant change: A 5% change in this measure will be considered significant.

Data adequacy: Medium

Measure 7: Index of presence and abundance of coniferous bog bird species

Description: Monitored every 5 years. This index is based on the following ten bird species: chipping sparrow, Connecticut warbler, golden-crowned kinglet, hermit thrush, Nashville warbler, red-breasted nuthatch, ruby-crowned kinglet, white-throated sparrow, winter wren, and yellow-rumped warbler. These birds were chosen because they specialize on some aspect of coniferous bog habitat. Refuge point count data recorded in the USGS Bird Point Count Database was used to determine presence and abundance of each species within the coniferous bog ecosystem (habitat code 384, field 841) of the Agassiz Wilderness. The following method of scoring was used:

Absent = 0
1-5 individuals observed = 1
6-15 individuals observed = 2
16-30 individuals observed = 3
Over 30 individuals observed = 4

The abundance scores were then summed across all ten species. This total score was divided by the number of points surveyed in field 841 for that year and multiplied by 100 to get the final index score. Further details can be viewed in Table 1, located in the Appendix section of this document. In general, the natural quality would be degraded if the index score decreases.

Context: The purpose of this measure is to gain knowledge regarding the overall health of the wilderness ecosystem as it pertains to animal and plant communities. As long as breeding bird point counts continue, there will be data for this measure. This makes it a favorable proxy for both plant and animal community health, as opposed to initiating new monitoring agendas for a number of specific species. It should be noted that, although the monitoring frequency for this measure was set at five years, data for this measure should be recorded whenever it is available (i.e. whenever a breeding bird survey is completed inside the wilderness). These surveys have not historically been completed within the wilderness at regular intervals. The frequency for this measure was marked down for every five years in the hopes that data collection within wilderness will become more consistent. A breeding bird survey did not take place on the Agassiz Wilderness in the year 2011.

Relevance to the indicator: Agassiz's unique ecosystems have a great deal to do with its federal wilderness designation. The status of these systems is therefore crucial to the natural quality of Agassiz's wilderness character. However, the health of any community or habitat type is very difficult to quantify. The use of proxy measures as trustworthy replacements for a long list of more specific measures is therefore a popular method of data acquisition. Birds tend to be relatively sensitive bio-indicator species and comprise a major proportion of wilderness-users among wildlife species. It was therefore determined that studying the presence and abundance of coniferous bog specialists among bird species was an adequate proxy for acquiring information about the health of plant and animal systems overall.

Data source: The Birds of North America website, Refuge point count data, professional judgment of Refuge biologist.

Process used to compile or gather the data: Review of the sources listed above and personal communication with Gregg Knutsen (Refuge biologist).

Significant change: Any change in this measure will be considered significant. Although this index was created with the best intention of accurately representing the health of the system, there is no proof that this will indeed be the case. This uncertainty, combined with the fact that index values are not meaningful in and of themselves, but only when compared over time, makes it necessary for any change in this measure to be marked as significant.

Data adequacy: Low. As of yet it is uncertain whether the index I created for this measure will do an adequate job of representing ecosystem health.

Measure 8: Index of presence and abundance of open bog bird species

Description: Monitored every 5 years. This index is based on the following ten bird species: alder flycatcher, cedar waxwing, great-crested flycatcher, common yellowthroat, warbling vireo, Nashville warbler, sedge wren, veery, white-throated sparrow, and yellow warbler. These birds were chosen because they specialize on some aspect of open bog habitat. Refuge point count data recorded in the USGS bird point count database was used to determine presence and abundance of each species within the open bog ecosystem (habitat code 383, fields 831 and 832) of the Agassiz Wilderness. The following method of scoring was used:

Absent = 0
1-5 individuals observed = 1
6-15 individuals observed = 2
16-30 individuals observed = 3
Over 30 individuals observed = 4

The abundance scores were then summed across all ten species. This total score was then divided by the number of points surveyed in fields 831 and 832 combined for that year and multiplied by 100 to get the final index score. Further details can be viewed in Table 2, located in the Appendix section of this document. In general, the natural quality would be degraded if the index score decreases.

Context: The purpose of this measure is to gain knowledge regarding the overall health of the wilderness ecosystem as it pertains to animal and plant communities. As long as breeding bird point counts continue, there will be data for this measure. This makes it a favorable proxy for both plant and animal community health, as opposed to initiating new monitoring agendas for a number of specific species. It should be noted that, although the monitoring frequency for this measure was set at 5 years, data for this measure should be recorded whenever it is available (i.e. whenever a breeding bird survey is completed inside the wilderness). These surveys have not historically been completed within the wilderness at regular intervals. The frequency for this measure was marked down for every 5 years in the hopes that data collection within wilderness will become more consistent. A breeding bird survey did not take place on the Agassiz Wilderness in the year 2011.

Relevance to the indicator: Agassiz's unique ecosystems have a great deal to do with its federal wilderness designation. The status of these systems is therefore crucial to the natural quality of Agassiz's wilderness character. However, the health of any community or habitat type is very difficult to quantify. The use of proxy measures as trustworthy replacements for a long list of more specific measures is therefore a popular method of data acquisition. Birds tend to be relatively sensitive bio-indicator species and comprise a major proportion of wilderness-users among wildlife species. It was therefore

determined that studying the presence and abundance of coniferous bog specialists among bird species was an adequate proxy for acquiring information about the health of plant and animal systems overall.

Data source: The Birds of North America website, Refuge point count data, professional judgment of Refuge Biologist.

Process used to compile or gather the data: Review of the sources listed above and personal communication with Gregg Knutsen (Refuge biologist).

Significant change: Any change in this measure will be considered significant. Although this index was created with the best intention of accurately representing the health of the system, there is no proof that this will indeed be the case. This uncertainty, combined with the fact that index values are not meaningful in and of themselves, but only when compared over time, makes it necessary for any change in this measure to be marked as significant.

Data adequacy: Low. As of yet it is uncertain whether the index I created for this measure will do an adequate job of representing ecosystem health.

Measure 9: Number of active bald eagle nests

Description: Monitored annually. This measure is a simple count of the number of bald eagle nests being actively utilized inside wilderness boundaries. Aerial surveys are flown each year to count the number of bald eagle nests and assess whether they are presently active or have been vacated since the previous year. The Refuge Biologist is in attendance during these flights. In general, the natural quality would be degraded if the number of active bald eagle nests decreases.

Context: Aerial surveys are flown over Agassiz NWR each year in May to gather data on bald eagle nesting sights. The flight path includes the Agassiz Wilderness, as six different nesting sights have been located there in various locations from 1992 to the present. Aerial surveys were initiated for the purpose of monitoring this threatened species as its populations had begun to recover. Bald eagle nesting data will continue to be collected in this manner for the foreseeable future. There were four active bald eagle nests in the Agassiz Wilderness in 2011.

Relevance to the indicator: Bald eagle populations began to decline in the mid-1900s due to the loss of appropriate nesting sights, shootings, and DDT. Until 2007, the species had been under some type of federal protection since 1940 (when Congress passed the Bald Eagle Protection Act). Bald eagles were listed as endangered throughout the contiguous 48 states (except in Minnesota, Michigan, Wisconsin, Washington, and Oregon where they were listed as threatened) under the Endangered Species Act of 1973. Protection of endangered species and administration of the Endangered Species Act is a top priority of the U.S. Fish and Wildlife Service, so projects were established throughout the country to monitor the status of our national symbol. Bald eagle populations had recovered enough by 2007 to be removed from the list of endangered and threatened species, and a key element of this success was the protection of crucial nesting sights. The monitoring of this previously-threatened species is an important part of Agassiz NWR's mission and, as a top predator among wilderness wildlife, it is an important part of wilderness character monitoring as well.

Data source: Electronic Refuge data records.

Process used to compile or gather the data: Simple analysis of eagle nest count data in spreadsheet form.

Significant change: An increase or decrease of 2 or more active nests will be considered significant.

Data adequacy: High

Indicator: Physical resources

Measures 10 – 13: Water quality of wilderness lakes and ditches

Description: Monitored a minimum of every three years. There are four measures in the database aimed at determining water quality within the wilderness. Three of these measures will record numeric values for the following: turbidity, dissolved oxygen, and specific conductivity. The fourth measure will record the natural resource specialist's professional opinion regarding the degree of nutrient loading in wilderness water. The nutrients to be analyzed are: Kjeldahl nitrogen, ammonia, nitrate, nitrite, orthophosphate, and total phosphorus. A look-up table will be provided in the database so that the resource specialist can identify the degree of contamination, on a scale from 0 to 10, with the following parameters:

0- None of the nutrients are present in water samples
1- One of the nutrients is present in water samples, but at a concentration that will likely have an insignificant effect on the plants, animals, and soil inside wilderness.
2- Two of the nutrients are present in water samples, but at concentrations that will likely have an insignificant effect on the plants, animals, and soil inside wilderness.
3- Three of the nutrients are present in water samples, but at concentrations that will likely have an insignificant effect on the plants, animals, and soil inside wilderness.
4- Four of the nutrients are present in water samples, but at concentrations that will likely have an insignificant effect on the plants, animals, and soil inside wilderness.
5- All five of the listed nutrients are present in water samples, but at concentrations that will likely have an insignificant effect on the plants, animals, and soil inside wilderness.
6- At least one nutrient is present in water samples at a concentration that will likely have a significant effect on the plants, animals, and/or soil inside wilderness.
7- At least two nutrients are present in water samples at concentrations that will likely have a significant effect on the plants, animals, and/or soil inside wilderness.
8- At least three nutrients are present in water samples at concentrations that will likely have a significant effect on the plants, animals, and/or soil inside wilderness.
9- At least four nutrients are present in water samples at concentrations that will likely have a significant effect on the plants, animals, and/or soil inside wilderness.
10- All five nutrients are present in water samples at concentrations that will likely have a significant effect on the plants, animals, and/or soil inside wilderness.

Monitoring locations will include Whiskey Lake, Kuriko Lake, and each of the three dikes that partially or fully bisect the wilderness. Data will be collected with a multiparameter probe (sonde) at three randomly determined shoreline locations at both Whiskey and Kuriko lakes. A water sample will be taken at one (randomly chosen) of these three locations. At each of the three ditches, data will be collected with the sonde and one water sample will be collected at a central point. See Map 1 in the Appendix section of this document for further details of sample locations.

Data will be collected with the sonde at three different times over the course of the open water season. These data will be collected by staff in simple "spot check" fashion during the following three timeframes: (1) no more than one week after peak spring runoff, (2) mid to late July within one day of a substantial (~ 1") rain event, and (3) mid to late October within one day of a substantial rain event. Seasonal climatic conditions during a given year will dictate whether the definition of a "substantial" rain event must be modified. During the collection of the above data, one discrete water sample (grab sample) will be collected at each monitoring location and analyzed for the above nutrients. Samples will be submitted for nutrient analysis via the Red Lake Watershed District. In general, the natural quality would be degraded if the magnitude of nutrient loads and other water quality parameters increases over time.

Context: Water is ubiquitous within the Agassiz Wilderness, but there is currently a paucity of information on the water quality of ditches that bisect the Agassiz Wilderness, as well as the water quality of Kuriko and Whiskey lakes. In order to obtain baseline water quality information and be able to monitor possible changes over time, it is critical that field data collection efforts are initiated in key locations. The protocol described here was developed in 2011 and will be initiated in the spring of 2012.

Relevance to the indicator: Water quality is a key natural resource for any wild place, especially one that has been designated to be "free from the effects of modern civilization." The effects of water quality degradations are innately pervasive, influencing plants, animals, and soils at every level of an ecosystem. Agassiz NWR is an island of wildlife surrounded by a sea of agriculture, so the possibility of water quality impairments does exist. Initiating this water sampling protocol is a critical component of wilderness character monitoring.

Data source: Red Lake Watershed District nutrient analysis report.

Process used to compile or gather the data: Field sampling along with laboratory processing and analysis.

Significant change: Any change in these measures will be considered significant.

Data adequacy: High

Measure 14: Air quality
All data for air quality measures will be monitored and entered by officials with the FWS I&M Program.

Monitoring question: What are the trends in terrestrial, aquatic, and atmospheric natural processes inside wilderness?

Indicator: Biophysical processes

Measures 15-17: Climate change measures
Description: Monitored every five years. A suite of three weather data measures was used in an attempt to gather information on climate change influences at a local level. Each measure utilizes data recorded by the Remote Automated Weather Station (RAWS), located on Agassiz NWR. These measures are:

mean summer temperature, mean winter temperature, and total summer precipitation. Summer was defined as the months of June, July, and August. Winter was defined as the months of December, January, and February. Mean summer and winter temperatures were calculated for each year. These seasonal means were then averaged over a five-year time interval. Since the year changes in the middle of the winter season, mean winter temperatures for any given year were calculated using data from December of the previous year and data from January and February of the target year. Total precipitation was calculated for the summer months (Minnesota's wet season) and then these seasonal totals were also averaged over a five-year time interval. In general, the natural quality would be degraded if mean summer or winter temperatures increase or if summer precipitation decreases.

Context: It is predicted that Minnesota will see a rise in winter temperatures of 4-8 degrees F and a rise in summer temperatures of 7-16 degrees F by the end of this century. Other climate change indicators for Minnesota include wetter winters and drier summers along with an increase in the frequency of extreme weather events. By using data from Agassiz's own RAWS station, these measures are meant to be an efficient way to monitor climate-related data. Data is accessible no earlier than November of 2002, so it was not possible to take five-year averages for time intervals previous to the current one (2007-2011).

Relevance to the indicator: Wilderness is set aside to preserve its natural conditions, but climate change has undeniable repercussions for natural system functioning. Attempting to monitor climate change and its widespread effects on wildlife is a national priority for many organizations, but there is no set protocol for how to do this in a cohesive manner. While the weather data measures described here are admittedly simplified proxies for representing climate change, they are an efficient means for Refuge staff to gather data directly linked to climate change and weather patterns.

Data source: RAWS weather data.

Process used to compile or gather the data: Excel analysis of weather data records.

Significant change: Any change in these measures will be considered significant, since most aberrations will be averaged out.

Data adequacy: Medium. Data is missing for 43 days over the course of the five-year winter interval. Data is missing for 35 days over the course of the five-year summer interval.

Measure 18: Number of deviations from water levels recommended for Thief Bay Pool and Webster Pool

Description: Monitored annually. Thief Bay Pool water levels are not to exceed 348.80 m (1,144.34 ft) above sea level. Webster Pool water levels are not to exceed 348.60 m (1143.69 ft) above sea level. Water levels at each water control structures are regularly monitored and recorded for impoundment and habitat management purposes. The number of times that water levels deviate from the above levels in the course of a year should be recorded under this measure. In general, the natural quality would be degraded if the number of deviations increases.

Context: There are no artificial impoundment pools inside the Agassiz Wilderness, but those that are adjacent (i.e., Thief Bay and Webster Pools) influence the natural water table of the wilderness. A Master's thesis completed in 2004 showed that black spruce and tamarack health is severely degraded

by short-term water table levels within 10 cm of the peat surface. Long-term water table levels within 30 cm of the peat surface will also suppress or kill peatland trees. If black spruce-tamarack forest health and composition is to be maintained, then a maximum water level of 348.80 m (1144.34 ft) above sea level for Thief Bay Pool and a maximum water level of 348.60 m (1143.69) above sea level for Webster Pool must not be exceeded. The Refuge staff has been very conscientious of this issue. Water management records (2009-2011) were reviewed and pool elevations never exceeded recommended levels.

Relevance to the indicator: The natural functioning of a bog ecosystem involves many ecological processes. The wilderness water table was being maintained at an artificially high level due to water management activities at the surrounding impoundment pools, and this was having a major effect on peatland tree health. Restoring the biophysical processes that involve peatland trees, soil, and water is crucial, and that necessitates monitoring.

Data source: Water management records.

Process used to compile or gather the data: Review of the records listed above.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

UNDEVELOPED QUALITY

The document *Keeping It Wild* states the following regarding the undeveloped quality: The Wilderness Act states that wilderness is "an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation," "where man himself is a visitor who does not remain" and "with the imprint of man's work substantially unnoticeable." This quality is degraded by the presence of structures, installations, habitations, and by the use of motor vehicles, motorized equipment or mechanical transport that increases people's ability to occupy or modify the environment.

Monitoring question: What are the trends in non-recreational development inside wilderness?

Indicator: Non-recreational structures, installations, and developments

Measure 19: Number of installations for research purposes

Description: Monitored annually. This measure is a count of the number of permanent or semi-permanent pieces of research equipment that are established inside wilderness. This measure should include anything from radio collars and ear tags to radio telemetry towers and observation decks. The number of individual installations should be summed for the year, regardless of the number of times

that they were used inside wilderness. In general, the undeveloped quality would be degraded if the number of installations increases.

Context: Research is a priority at Agassiz NWR and there are often research projects that take place inside the wilderness. While these projects are initiated with the purpose of furthering our understanding of the natural features and processes inside the wilderness, it is crucial that the impacts of these projects do not outweigh their benefits. This measure was developed in order to ensure that research impacts are monitored, and mitigated if necessary. So far, the research projects that have occurred inside the Agassiz Wilderness have been relatively low-impact and minimum tool analyses were always completed. In 2011 there were 0 installations for research purposes inside the wilderness.

Relevance to the indicator: Research inside wilderness leads to increased knowledge of natural ecosystem functioning, and it should often be a priority. However, research projects can sometimes have severe impacts on the land or on the plant or animal of study. It is crucial that land managers think about the effects of a given project on wilderness character before authorizing it. It may be that certain projects should only be authorized in wilderness if they cannot be completed adequately anywhere else on the Refuge.

Data source: Annual narratives, minimum requirement analyses, professional judgment of Refuge manager and Refuge biologist, Mark Ditmer (University of Minnesota researcher on a bear study that took place on Agassiz NWR), Kyle Johnson (University of Wisconsin researcher on a lepidopteran study inside the wilderness)

Process used to compile or gather the data: Review of the documents listed above and personal communication with Refuge staff and researchers.

Significant change: An increase or decrease of two or more installations will be considered significant.

Data adequacy: High

Measure 20: Miles of dike that bisect the wilderness

Description: Monitored every five years. This measure sums the total length (in miles) of the Wilderness Dike that bisects the Agassiz Wilderness. In general, the undeveloped quality would be improved if this mileage decreases (due to restoration activities, natural wilderness community overgrowth on the dike, etc.).

Context: The Wilderness Dike refers to the dike and associated drainage ditches that cut through the wilderness but are officially exempt from wilderness designation. This dike serves as the main access point for most foot traffic into the wilderness. Although it is technically outside wilderness boundaries, Refuge staff does not mow or maintain the dike and there has been talk of allowing the dike to grow over. The dike runs a length of 2.46 miles through the wilderness at present, and while it is not maintained, this number is not likely to change unless active restoration efforts occur.

Relevance to the indicator: Wilderness is a place where “the imprint of man’s work [is] substantially unnoticeable.” While the Wilderness Dike has been officially excluded from the Agassiz Wilderness since its designation, it still has a significant impact on the character of this wilderness. Additionally, if

restoration efforts ever occur they will be recorded under the untrammeled quality and it is important to capture the benefits of such actions as well. This necessitates monitoring.

Data source: Refuge GIS data, Refuge biologist.

Process used to compile or gather the data: Personal communication with Gregg Knutsen (Refuge biologist).

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

Measure 21: Number of unauthorized, non-recreational physical developments

Description: Monitored annually. This measure is a count of all observed structures that could be categorized as unauthorized, non-recreational development. Examples of this include fences, roads to inholdings, water catchments, fixed instrumentation sights, radio repeaters, etc. Data for this measure relies on personal observation of Refuge staff, especially during aerial surveys that occur for other monitoring and management purposes. In general, the undeveloped quality would be degraded if the number of developments increases.

Context: Several aerial surveys are flown over the Agassiz Wilderness each year. These include an eagle nest count survey and breeding duck pair survey (completed concurrently in May), an infrared image flight (mid-August) and a big game survey (late winter). Unauthorized developments are not an issue for the Agassiz Wilderness, nor are they likely to be an issue in the future. This measure is a low priority, but since aerial surveys will be flown each year for other monitoring purposes, it will be a simple procedure for Refuge staff in attendance to keep track of any unauthorized, non-recreational developments they may observe inside wilderness.

Relevance to the indicator: As land set aside to retain its primeval character, it is critical that wilderness is not misused by visitors. The unauthorized development of temporary or permanent structures inside wilderness is a severe hindrance to the maintenance of wilderness character, and therefore necessitates monitoring.

Data source: Annual narratives, Refuge staff.

Process used to compile or gather the data: Review of annual narratives and personal communication with Refuge staff.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

Indicator: Inholdings

Measure 22: Acres of inholdings

Description: Monitored every five years. This measure calls for a sum of the total area (in acres) of any inholding(s) located within wilderness. In general, the undeveloped quality would be degraded if the acreage of inholdings increases.

Context: There are no private of public inholdings within the Agassiz Wilderness. This is unlikely to change given that the entire wilderness is under the control of the federal government and protected under the Wilderness Act of 1964. This measure has low significance to this particular wilderness and has been included only in order to represent this indicator within the wilderness character monitoring framework.

Relevance to the indicator: A summation of the area of inholdings is directly linked to the indicator called "Inholdings". Many wilderness areas across the U.S. have acreages of privately or publicly owned land inside their borders. The use of this land can clearly and easily affect what happens inside that wilderness. It is therefore important to monitor the amount of land in these inholdings.

Data source: Wilderness Study, professional judgment of Refuge staff.

Process used to compile or gather the data: Review of the Agassiz Wilderness Study and personal communication with Refuge staff.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

Indicator: Use of motor vehicles, motorized equipment, or mechanical transport

Measure 23: Index of authorized motor vehicle, motorized equipment, or mechanical transport usage
Definition: Monitored annually. Each piece of equipment used within wilderness is placed into one of five categories and given a corresponding impact score as follows: mechanical transport (score = 1), low-impact motorized equipment (score = 2), high-impact motorized equipment (score = 3), low-impact motor vehicle (score = 3), or high-impact motor vehicle (score = 4). The score for each category is then multiplied by the number of days of usage for any and all pieces of equipment that fall into that category. The products are added across categories to obtain the final index value. Scores on the index can range from 0 to 4,745. Further details can be viewed in Table 3, located in the Appendix section of this document. Pieces of motorized research equipment should not be counted in this index because they are already recorded under Measure 19. In general, the undeveloped quality would be degraded if the index score increases.

Context: There has been little to no use of motor vehicle, motorized equipment, or mechanical transport usage inside the wilderness, and this is unlikely to increase in the future. The 2011 index score for the Agassiz Wilderness is zero. However, there is always a potential for situations to arise where this type of equipment would be condoned. One such situation would be if a wildfire started in or entered the wilderness and put neighboring private properties at risk.

Relevance to the indicator: Wilderness is a place where "the imprint of man's work [is] substantially unnoticeable" and has been set aside to retain its primeval character. The use of motorized vehicles and equipment not only creates artificial and clearly man-made noise within the wilderness, but it also

leaves behind significant signs of man's invasion into the wilderness. The use of mechanical transport disrupts the primeval character of wilderness. It prevents those who use or observe such equipment from being fully exposed to the wilderness and it serves as a stark reminder of man's presence.

Data source: Annual narratives, Minimum Requirement Analyses, professional judgment of Refuge staff.

Process used to compile or gather the data: Review of the documents listed above and personal communication with Refuge staff.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

Measure 24: Number of two-track trails created by unauthorized vehicle use
Definition: Monitored annually. This measure is a count of obvious vehicular invasions into the wilderness. A vehicle trail will be defined as any area with disturbed vegetation created by two parallel lines (considered a two-track trail). Data for this measure relies on personal observation of Refuge staff, especially during aerial surveys that occur annually for other monitoring and management purposes. In general, the undeveloped quality would be degraded if the number of vehicle trails increases.

Context: Several aerial surveys are flown over the Agassiz Wilderness each year. These include an eagle nest count survey and breeding duck pair survey (completed concurrently in May), an infrared image flight (mid-August) and a big game survey (late winter). Unauthorized vehicular invasions are not an issue for the Agassiz Wilderness, nor are they likely to be an issue in the future. This measure is a low priority, but since aerial surveys will be flown each year for other monitoring purposes, it will be a simple procedure for Refuge staff in attendance to keep track of any two-track trails they may observe inside wilderness.

Relevance to the indicator: As land set aside to retain its primeval character, it is critical that wilderness is not misused by visitors. The unauthorized use of vehicles inside wilderness is a severe hindrance to the maintenance of wilderness character, and therefore necessitates monitoring.

Data source: Annual narratives, professional judgment of Refuge staff.

Process used to compile or gather the data: Review of the documents listed above and personal communication with Refuge staff.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

Monitoring question: What are the trends in cultural resources inside wilderness?

Indicator: Loss of statutorily protected cultural resources

Measure 25: Number of disturbances to cultural resources inside wilderness
Definition: Monitored every five years. This measure should simply be a count of the number of disturbances to statutorily protected cultural resources inside wilderness. Disturbances may include vandalism, construction, damage from wildlife, etc. In general, the undeveloped quality would be degraded if the number of disturbances to cultural resources increases.

Context: This is not a concern for the Agassiz Wilderness. An in-depth Cultural Resources study has taken place at Agassiz NWR, and while there are significant cultural resources on the Refuge, none of these are within the wilderness, as it has always been a boggy area that is largely uninhabitable. This measure has low relevance to this particular wilderness and has been included only in order to represent this indicator within the wilderness character monitoring framework.

Relevance to the indicator: Recording the number of disturbances to cultural resources is directly linked to the indicator called "Loss of statutorily protected cultural resources". Many wilderness areas across the U.S. hold statutorily protected cultural resources. These cultural resources may be protected by law or agency policy. While cultural resources are often manmade structures, they are irreplaceable relics of a time when human history was intertwined with nature. They reflect the primeval character of wilderness and have often been in place for hundreds of years. They are a crucial part of human history and the wilderness' history as well. It is therefore important to monitor the degradation or disturbance of these resources by authorized, unauthorized, or natural means.

Data source: Cultural Resources Management Plan, Wilderness Management Plan.

Process used to compile or gather the data: Review of the documents listed above.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

SOLITUDE OR PRIMITIVE AND UNCONFINED RECREATION QUALITY

The document *Keeping It Wild* states the following regarding the solitude or primitive/unconfined recreation quality: The Wilderness Act states that wilderness has "outstanding opportunities for solitude or a primitive and unconfined type of recreation." This quality is about the *opportunity* for people to experience wilderness; it is not directly about visitor experiences per se. This quality is degraded by settings that reduce these opportunities, such as visitor encounters of modern civilization, recreation facilities, and management restrictions on visitor behavior.

Monitoring question: What are the trends in outstanding opportunities for solitude inside wilderness?

Indicator: Remoteness from sights and sounds of people inside the wilderness

Measure 26: Percent of wilderness affected by access or travel routes
Description: Monitored every five years. This measure records the percent of the wilderness that lies within certain buffer distances from roads or other access routes, either inside or adjacent to

wilderness. A buffer distance of 1/2 mile was used for open or motorized roads and a buffer distance of 1/4 mile was used for non-motorized or unmaintained roads. This measure requires some simple analysis with ArcGIS software. In general, the solitude quality would be degraded if the percent of wilderness within these buffer distances increases.

Context: Agassiz NWR has a network of maintained, gravel roads for Refuge staff use. These roads make many water and habitat management activities possible. Some of these roads come within close proximity of the wilderness but the major factor influencing this measure is the Wilderness Dike, an unmaintained corridor cutting through the middle of the wilderness. This is the main reason that 31.65% of the wilderness is within the stated buffer distances from access or travel routes.

Relevance to the indicator: The inclusion of a measure relating to wilderness use is critical to this indicator and the solitude quality. A greater amount of use would affect the feelings of peace and calm necessary to attain a sense of solitude. The Agassiz Wilderness has very little recreation use, but this indicator is aimed at tracking the amount of actual and *potential* use that a wilderness may have, thus monitoring a visitor's ability to get away and find solitude. This measure serves as a course estimate of the area of wilderness frequented by visitors or the area of wilderness easily accessed by visitors with the potential for frequent visitation.

Data source: Refuge GIS data.

Process used to compile or gather the data: Analysis of Refuge GIS data.

Significant change: A 5% change in this measure will be considered significant.

Data adequacy: Medium. The GIS layers used to calculate this percentage had some inaccuracies. They reported the area of the wilderness to be 5,096 acres, when it is legally only 4,000 acres. This will make the percentage recorded here inaccurate, but the measure will still be useful in monitoring trend and change over time.

Indicator: Remoteness from occupied and modified areas outside the wilderness

Measure 27: Artificial night sky brightness

Description: Monitored every ten years. This measure requires the use of an official artificial night sky brightness map to complete a visual examination of which brightness ratio category the area of the wilderness falls into. These maps are displayed such that colors correspond to ratios between the artificial night sky brightness and the natural night sky brightness of: <0.01 (black), 0.01-0.11 (dark gray), 0.11-0.33 (blue), 0.33-1 (green), 1-3 (yellow), 3-9 (orange), 9-27 (red), <27 (white). The Agassiz Wilderness falls entirely within the dark gray category, which implies a very low ratio of artificial brightness to natural brightness. This measure assigns a numerical value to each brightness ratio color class from best (black = 1) to worst (white = 8). Since the Agassiz Wilderness is in the second to lowest category it receives a 2.

If the wilderness ever falls into more than one artificial brightness category, the area of wilderness within each category should be calculated and converted to a percentage. For the purposes of this measure, the wilderness would be classified into whichever category holds the highest percentage of wilderness area, but the other categories and percentages should be marked down in the comments

section of the database. In general, the solitude quality would be degraded if the artificial night sky brightness ratio increases (moves on the color scale from black toward white).

Context: The Agassiz Wilderness is "off the beaten path". The closest town of substantial size is Thief River Falls, which has less than 10,000 residents. It is located 23 miles from the Refuge headquarters and approximately 26 miles from the wilderness boundary. The closest city with a population of over 25,000 is Grand Forks, ND, located 75 miles to the southwest of the Refuge. Therefore, there is very little light pollution in the area, creating incredibly clear night skies. The global dataset used for this measure was developed in 2000 and it is uncertain when such a project will be repeated. In order to continue monitoring night sky brightness, the Refuge could consider purchasing a handheld Sky Quality Meter (SQM) for approximately $120.00 which would allow data to be collected at a much more local scale. The SQM measures the brightness of the night sky in magnitudes per square arcsecond. If the Refuge decides to start collecting data in this way, a protocol should be written up and entered into the database to ensure consistency.

Relevance to the indicator: This indicator is aimed at monitoring the condition of areas surrounding wilderness that may affect a visitor's opportunities for solitude. Although land managers cannot control these external factors, they can sometimes have significant impacts on wilderness character. Night sky visibility is a component of the social meanings we place on wilderness. Wilderness values such as humility, restraint, and interdependence are critical aspects of wilderness character, so the extent of one's ability to experience them must be monitored.

Data source: Cinzano et al. (2000) and The Night Sky in the World website

Process used to compile or gather the data: Interpretation of Cinzano's article and visual classification of the Agassiz Wilderness based on a wilderness boundary layer overlaid on an artificial night sky brightness map in ArcGIS.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

Monitoring question: What are the trends in outstanding opportunities for primitive and unconfined recreation inside wilderness?

Indicator: Facilities that decrease self-reliant recreation

Measure 28: Number of user-created recreation facilities

Definition: Monitored annually. This is a count of all structures that could be categorized as recreational development and were built or installed by users of the wilderness. Examples of this include shelters, trails, campsites, bridges, bear boxes, etc. Data for this measure relies on personal observation of Refuge staff, especially during aerial surveys that occur annually for other monitoring and management purposes. In general, the primitive and unconfined recreation quality would be degraded if the number of facilities increases.

Context: Several aerial surveys are flown over the Agassiz Wilderness each year. These include an eagle nest count survey and breeding duck pair survey (completed concurrently in May), an infrared image flight (mid-August) and a big game survey (late winter). User-created recreation facilities are not an issue for the Agassiz Wilderness, nor are they likely to be an issue in the future given its relative inaccessibility and boggy nature. This measure has low relevance to this particular wilderness, but is necessary to represent this indicator. Since aerial surveys will be flown each year for other monitoring purposes, it will be a simple procedure for Refuge staff in attendance to keep track of any user-created recreation facilities they may observe inside wilderness.

Relevance to the indicator: *Keeping It Wild* states that "opportunities for primitive and unconfined recreation are most outstanding where visitors must rely on their own skills to navigate, travel, and live…" This measure is aimed at tracking a visitor's opportunity to fully experience wilderness. Structures, installations, or developments that have a recreation purpose degrade a visitor's perceived opportunity for primitive and unconfined recreation, and thus necessitate monitoring.

Data source: Annual narratives, Refuge staff.

Process used to compile or gather the data: Review of the documents listed above and personal communication with Refuge staff.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

Indicator: Management restrictions on visitor behavior

Measure 29: Index of management restrictions on visitor behavior

Description: Monitored annually. This measure is a weighted index of restrictions on visitor behavior. Scores range from 0 to 3 based on the type of restriction for each of 10 regulation categories. These scores are then weighted by geographic extent, where a weight of 1 applies to a restriction that covers only a subarea of the wilderness, and a weight of 2 applies to a restriction that is wilderness-wide. Scores for each regulation category are multiplied by their geographic extent. These products are then summed across all categories. Scores on the index can range from 0 to 36. Further details can be viewed in Table 4, located in the Appendix section of this document. In general, the primitive and unconfined recreation quality would be degraded if the index score of management restrictions increases.

Context: Management restrictions on visitor behavior are a complex issue in the Agassiz Wilderness. Most recreational activities are prohibited in the wilderness, but this is because they are incompatible with the Refuge's establishing purposes of prioritizing wildlife above all else, including recreational opportunities for visitors. While this has degraded opportunities for primitive recreation, it has preserved the natural quality and helped to maintain a sense of solitude for those that do visit the wilderness. The 2011 index score for the Agassiz Wilderness is fourteen.

Relevance to the indicator: The extent of management restrictions on visitor behavior is an important component of primitive and unconfined recreation. It relates to the ability to experience freedom of choice and to exercise a high degree of freedom over one's actions and decisions. *Keeping It Wild* states that "visitors' opportunities to experience freedom from management are significantly affected by the

number and type of regulations in place." The type and extent of these regulations therefore require monitoring.

Data source: Wilderness Management Plan, Agassiz NWR and State WMA Rules & Regulations, Agassiz NWR Deer Hunting Map and Regulations brochure.

Process used to compile or gather the data: Review of the documents listed above.

Significant change: Any change in this measure will be considered significant.

Data adequacy: High

MEASURES NOT USED

NATURAL QUALITY

Number of indigenous species that are endangered/threatened
Reason: There was no readily available data for this measure. It was also assigned a low priority level since there are no known endangered and/or threatened species residing in the wilderness. It would therefore not have been worth the time and effort to develop a system for accurately calculating this measure.
Priority ranking: Low

Number of extirpated indigenous species
Reason: There was no readily available data for this measure. Given its low priority level, it would not have been worth the time and effort to develop a system of accurately calculating this measure.
Priority ranking: Low

Extent of impact on vegetation due to altered water flow from the Wilderness Dike and associated ditches
Reason: There is no data for such a measure. Greater knowledge of the impacts of the Wilderness Dike would be a helpful management tool, but this would require a time-intensive and in-depth research study. A study of this nature was originally planned as part of Rhett Johnson's Master's thesis but was never completed. Refuge staff does not have the resources to take on this type of study at present.
Priority ranking: Medium

Presence of chemical contaminants in wilderness soil
Reason: There is no data for this measure and Refuge staff has no plans for such data to be gathered in the near future.
Priority ranking: Medium

Total summer evapotranspiration
Reason: This was originally part of the suite of weather data measures being used in an attempt to gather information on climate change influences at a local level. Although changes in evapotranspiration rates are a relatively strong indicator of climate change effects, this measure was removed for several reasons. The RAWS weather data being used was missing evapotranspiration data for far more days

than any of the other parameters being recorded. It was also removed because there is significant debate regarding the most accurate way to calculate this physical process.
Priority ranking: Medium

Area of pathways for movement of non-indigenous plant species into wilderness
Reason: There was no readily available data for this measure. Given its low priority level, it would not have been worth the time and effort it would have taken to develop a system of calculating this measure.
Priority ranking: Low

Loss of connectivity with the surrounding landscape
Reason: There was no data for this measure and the development of an appropriate process for measuring connectivity in a straightforward way proved very complex.
Priority ranking: Medium

Departure from natural fire regime
Reason: There was no readily available data for this measure. Given its low priority level, it would not have been worth the time and effort it would have taken to develop a system of calculating this measure.
Priority ranking: Low

UNDEVELOPED QUALITY

Number of administrative installations
Reason: A measure called "Number of authorized developments" was split into this measure and a measure called "Number of installations for research purposes". The original measure had a medium priority level, but once they were split this component proved to be of low priority and low relevance to the Agassiz Wilderness. There are no administrative installations inside the wilderness and none are planned for the foreseeable future.
Priority ranking: Low

SOLITUDE OR PRIMITIVE AND UNCONFINED RECREATION QUALITY

Number of visitor-days of wilderness usage per year
Reason: There is no data for this measure. Visitor usage is a relatively important component of the solitude quality, thus the priority level assigned to this measure. However, there is no system in place to collect this type of information.
Priority ranking: Medium

Number of agency-provided recreation facilities
Reason: While the priority level is medium based on importance, vulnerability, reliability, and reasonableness, this measure has very little relevance to the Agassiz Wilderness. There are no agency-provided recreation facilities inside wilderness, nor are there likely to be any in the foreseeable future. The Agassiz Wilderness Study explicitly states that no facilities will ever be provided in the wilderness.
Priority ranking: Medium

CONCLUSIONS

The overall status of the Agassiz Wilderness is very good. The natural systems are basically intact, most natural processes are allowed to function freely, and it requires relatively few management actions. Additionally, there is very little recreational use of the wilderness, mostly due to its isolated, boggy and often inhospitable nature. The chances of unauthorized actions taking place or of facilities being developed inside wilderness are therefore very slim.

In my opinion, the spread of invasive species is the greatest threat to the Agassiz Wilderness at present. Invasive species not only have the potential to degrade the natural quality of wilderness by wiping out native communities, but they could also lead to degradations of the untrammeled quality as management actions become necessary to ameliorate the damage they cause. The main point of access that species such as reed canary grass or Canada thistle have into the wilderness is from the Wilderness Dike, which is a problem in and of itself. This dike cutting through wilderness is clearly disturbed from what would be considered a natural ecological balance, which makes it a breeding ground for exotic and/or indigenous invasive species. These species then have ample opportunity to spread seed into the wilderness by any number methods. Although exempt from wilderness designation, the dike and associated ditches cause other disturbances to wilderness character as well. Their presence alters the historical flow of ground and surface water, impacts surrounding vegetation, and serves as a permanent scar of human manipulation in the middle of the wilderness.

I believe that the wilderness character monitoring plan laid out in this document has taken into account all these issues unique to the Agassiz Wilderness; may they be positive, negative, or neutral. The plan accounts for certain necessary degradations to one aspect of wilderness character by recording the positive results of such actions under another aspect. The plan responds to all nationally required wilderness character indicators, while taking care to include only measures that are actually relevant within the unique set of conditions at the Agassiz Wilderness. For the most part, it uses only data that is already routinely collected or is very simple to collect. The only exception to this statement is the new water quality monitoring protocol. This protocol has added to the workload at Agassiz NWR, but Refuge staff was enthusiastic about the inclusion of such measures given their legitimate concerns over agricultural contaminants in Refuge and wilderness waterways.

It should be made clear that the plan laid out in this document could not possibly capture the entire essence of the Agassiz Wilderness. The measures included for the wilderness character monitoring framework should not be misconstrued as the only aspects of the wilderness that hold value. It should also be noted that, at first glance, the undeveloped and solitude qualities may seem less represented than the untrammeled or natural qualities. This was not done purposely in order to represent any type of bias among the four measures. The only reasons for this discrepancy are a lack of data sources and a lack of need. As for the former, there is no data, nor any system in place to collect data, on visitation to the wilderness or soundscape monitoring. As for the latter, the time and effort of Refuge staff would not be well spent collecting data on such things as campsites, agency-provided facilities, or administrative developments inside wilderness because these items do not exist in the Agassiz Wilderness nor are they likely to in the future. If for any reason these circumstances change, measures to represent their effects on wilderness character should be developed and entered into this framework.

In order to approach the few areas where data were somewhat lacking, the following potential projects would benefit wilderness character monitoring in the future:

- Initiation of a soundscape monitoring project
- Continuation of night sky brightness monitoring by purchasing a Sky Quality Meter (see Measure 27)
- Initiation of a protocol for estimating wilderness visitation (e.g. inquiring of visitors as to whether they will be visiting the wilderness when they come to the headquarters to obtain a gate key)
- Initiation of a study pertaining to the extent of impact on vegetation due to altered water flow of the Wilderness Dike and associated ditches

While data from these projects would clearly aid wilderness character monitoring efforts, it is also understood that Refuge staff time is limited and is often stretched too thin. The addition of these projects may not be feasible in the near future, but they are nonetheless things to consider. The overarching conclusion that must be drawn from this project is that the Agassiz Wilderness is a vibrant representation of wilderness qualities and values. It is truly a lot of wilderness in a small, 4,000-acre package.

DOCUMENTS CONSULTED

REFUGE DOCUMENTS:

Johnson, R. 2006. Peatland Trees and Hydrology: A Dendrochronological Examination of Black Spruce and Tamarack Growth and Associated Hydrology in a Peatland in Marshall County, Minnesota. A Thesis for the University of Minnesota.

Agassiz National Wildlife Refuge: A Cultural Resources Survey of Agassiz National Wildlife Refuge. U.S. Fish and Wildlife Service. 1977 and 2002. Print.

Agassiz National Wildlife Refuge: Comprehensive Conservation Plan (2005-2020). U.S. Fish and Wildlife Service. July 19, 2005. Print.

Agassiz National Wildlife Refuge: Habitat Management Plan. U.S. Fish and Wildlife Service. 2007. Print.

Agassiz National Wildlife Refuge: Fire Management Plan. U.S. Fish and Wildlife Service. 2009. Print.

Agassiz National Wildlife Refuge: Wilderness Management Plan. U.S. Fish and Wildlife Service. 1981. Print.

Agassiz National Wildlife Refuge: Wilderness Study. U.S. Fish and Wildlife Service. 1973. Print.

REFUGE FILES:

Wilderness Files
Water Management File
Contaminant Study File
Annual Narratives (1976-2003)

JOURNAL ARTICLES AND WEBSITES:

Cinzano, P. et al. 2000. The artificial night sky brightness mapped from DMSP satellite Operational Linescan System measurements. Royal Astronomical Society. Reproduced from the Monthly Notices of the RAS by permission of Blackwell Science.

The Night Sky in the World website: www.lightpollution.it/dmsp/

Agassiz RAWS Data website: http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?sdMAGA

Birds of North America Online website: http://bna.birds.cornell.edu/bna/

National Bird Point Count Database: http://www.pwrc.usgs.gov/point/

WILDERNESS CHARACTER MONITORING RESOURCES:

Landres et al. 2008. Keeping It Wild: An Interagency Strategy to Monitor Trends in Wilderness Character Across the National Wilderness Preservation System. US Department of Agriculture, Forest Service: General Technical Report RMRS-GTR-212.

Landres et al. 2009. Technical Guide for Monitoring Selected Conditions Related to Wilderness Character. US Department of Agriculture, Forest Service: General Technical Report WO-80.

APPENDICES

WORKSHEETS: PRIORITIZING MEASURES OF WILDERNESS CHARACTER

In each row, write the indicator and potential measure in the left column. Use the following criteria and ranking guide to create an overall score for each measure. Those measures with the highest overall scores should be the highest priority for assessing trends in wilderness character.

- Level of importance: measure is highly relevant to the quality and indicator of wilderness character, and is highly useful for managing the wilderness. High = 3, Medium = 2, Low = 1
- Level of vulnerability: measures the level to which an attribute of wilderness character is currently at risk or might likely be at risk over the next 10-15 years. High = 3, Medium = 2, Low = 1
- Degree of reliability: measure can be monitored accurately with a high degree of confidence and would yield the same result if measured by different people at different times. High = 3, Medium = 2, Low = 1
- Degree of reasonableness: measure is related to an existing effort or could be monitored without significant additional effort. High = 1, Low = 0

QUALITY: UNTRAMMELED

Potential Measure	Criteria for Prioritizing Potential Measures				
	Importance	Vulnerability	Reliability	Reasonableness	OVERALL SCORE
Indicator: Actions authorized by the Federal land manager that manipulate the biophysical environment Measure: Number of actions to manage plants	3	3	2	1	9
Indicator: Actions authorized by the Federal land manager that manipulate the biophysical environment Measure: Number of actions to manage animals	2	2	3	1	8
Indicator: Actions authorized by the Federal land manager that manipulate the biophysical environment Measure: Number of actions to manage water/soil	3	3	3	1	10
Indicator: Actions authorized by the Federal land manager that manipulate the biophysical environment Measure: Number of actions to manage					

Potential Measure	Criteria for Prioritizing Potential Measures: Importance	Vulnerability	Reliability	Reasonableness	OVERALL SCORE
fire	2	2	2	1	7
Indicator: Actions ***not*** authorized by the Federal land manager that manipulate the biophysical environment Measure: Number of unauthorized actions taken by agencies, citizen groups, or individuals that influence the community of life inside wilderness	1	1	2	1	5

STOP!

If A + B ≤ 2

QUALITY: NATURAL

Potential Measure	Criteria for Prioritizing Potential Measures: Importance	Vulnerability	Reliability	Reasonableness	OVERALL SCORE
Indicator: Plant and animal species and communities Measure: Number of indigenous species that are endangered/threatened	2	2	1	0	5
Indicator: Plant and animal species and communities Measure: Number of extirpated indigenous species	1	2	1	0	4
Indicator: Plant and animal species and communities Measure: Distribution of invasive, non-indigenous plant species	3	3	2	1	9
Indicator: Plant and animal species and communities Measure: Distribution of invasive, indigenous plant species	3	3	2	1	9

Indicator: Plant and animal species and communities Measure: Index of presence and abundance of focal bird indicator species	3	2	2	1	8
Indicator: Plant and animal species and communities Measure: Number of active bald eagle nests inside wilderness	3	1	2	1	7
Indicator: Plant and animal species and communities Measure: Extent of impact on vegetation due to altered water flow from wilderness dike and associated ditches	3	3	1	0	7
Indicator: Physical resources Measure: Presence/amount of agricultural and other contaminants in wilderness lakes and/or adjacent ditches	3	3	3	0	9
Indicator: Physical resources Measure: Presence of chemical contaminants in soil	2	2	3	0	7
Indicator: Biophysical processes Measure: Extent/magnitude of global climate change (RAWS)	2	2	2	1	7
Indicator: Biophysical processes Measure: Area of pathways for movement of non-indigenous plant species into wilderness	1	3	1	0	5
Indicator: Biophysical processes Measure: Loss of connectivity with the surrounding landscape	3	3	1	0	7
Indicator: Biophysical processes Measure: Number of deviations from recommended water levels	3	3	3	1	10
Indicator: Biophysical processes	2	2	1	0	5

Measure: Departure from natural fire regime					

QUALITY: UNDEVELOPED

Potential Measure	Criteria for Pri...		...al Measures		
	Importance	Vu...	...y	Reasonableness	OVERALL SCORE
Indicator: Non-recreational structures, installations, and developments Measure: Number of authorized physical developments	2	1	3	1	7
Indicator: Non-recreational structures, installations, and developments Measure: Miles of wilderness dike bisecting the wilderness	3	3	3	1	10
Indicator: Non-recreational structures, installations, and developments Measure: Number of unauthorized physical developments	2	1	1	1	5
Indicator: Inholdings Measure: Acres of inholdings	1	1	3	1	6
Indicator: Use of motor vehicles, motorized equipment, or mechanical transport Measure: Index of type and amount of authorized use	2	1	3	1	7
Indicator: Use of motor vehicles, motorized equipment, or mechanical transport Measure: Number of trails from unauthorized vehicle use	2	1	1	1	5
Indicator: Loss of statutorily protected cultural resources Measure: Number of disturbances	1	1	3	1	6

STOP!

If A + B ≤ 2

STOP!

If A + B ≤ 2

QUALITY: SOLITUDE OR PRIMITIVE AND UNCONFINED RECREATION

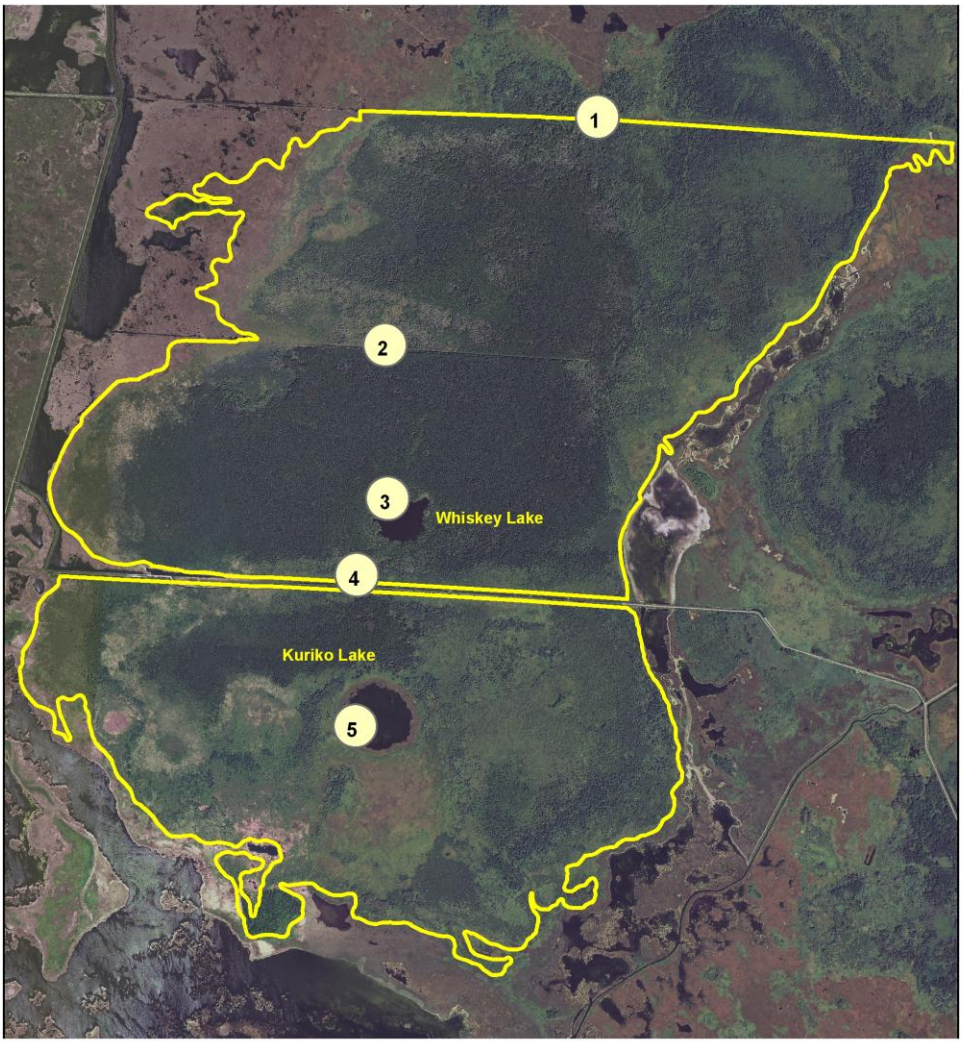
Potential Measure	Criteria for Prioritizing Potential Measures: Importance	Vulnerability	Reliability	Reasonableness	OVERALL SCORE
Indicator: Remoteness from sights and sounds of people inside the wilderness Measure: Amount of visitor use	2	1	2	1	6
Indicator: Remoteness from sights and sounds of people inside the wilderness Measure: Percent of wilderness affected by access or travel routes	2	2	3	1	8
Indicator: Remoteness from occupied and modified areas outside the wilderness Measure: Artificial night sky brightness	3	1	2	1	7
Indicator: Facilities that decrease self-reliant recreation Measure: Number of agency-provided facilities inside wilderness	2	1	3	1	7
Indicator: Facilities that decrease self-reliant recreation Measure: Number of user-created facilities inside wilderness	2	1	1	0	4
Indicator: Management restrictions on visitor behavior Measure: Number of permitted visitor activities to which management restrictions are applied	2	2	3	1	8

STOP!

If A + B ≤ 2

MAP 1: Depiction of water sampling points for water quality monitoring measures

Agassiz NWR Water Quality Monitoring Locations



Coordinate Locations of Monitoring Sites

1 - N = 5364732, E = 0281713
2 - N = 5363179, E = 0280274
3 - N = 5362020, E = 0280398 (lake centroid)
4 - N = 5361606, E = 0280088 (north-most ditch)
5 - N = 5360685, E = 0280222 (lake centroid)

TABLE 1: Example of coniferous bog bird indicator species index

Total # of survey points in coniferous bog habitat = 56	
Coniferous Bog - 2010 (3 points finished in 2011)	
Species	**Abundance Score**
Chipping Sparrow	4
Connecticut Warbler	1
Golden-crowned Kinglet	4
Hermit Thrush	2
Nashville Warbler	4
Red-breasted Nuthatch	2
Ruby-crowned Kinglet	2
White-throated Sparrow	4
Winter Wren	1
Yellow-rumped Warbler	4
Total Score =	28
# of points =	55
Index value =	50.90909091

TABLE 2: Example of open bog bird indicator species index

Total # of survey points in open bog habitat = 25	
Open Bog - 2008	
Species	**Abundance Score**
Alder Flycatcher	3
Cedar Waxwing	2
Great-crested flycatcher	1
Common Yellowthroat	3
Warbling vireo	2
Nashville Warbler	1
Sedge Wren	1
Veery	2
White-throated Sparrow	3
Yellow Warbler	4
Total Score =	22
# of points=	11
Index score=	200

TABLE 3: Index of authorized motor vehicle, motorized equipment, or mechanical transport usage

Authorized Use- 2011				
Type of equipment	**Examples (not all-inclusive)**	**Score**	**Days of Usage**	**Index Value**
Mechanical Transport		1	0	0
	Bicycle			
	Game/canoe cart			
	Wheelbarrow			
Motor Vehicle- low impact		3	0	0
	Truck/car/motorcycle etc.			
	Track vehicle (Marsh-master, bombardier, Scout, Kubota, etc.)			
	Recreational vehicle (ATV, snowmachine, etc.)			
	Fixed-wing aircraft			
	Float plane			
	Helicopter			
Motor Vehicle- high impact		4	0	0
	Heavy equipment			
	Concrete equipment			
	Construction vehicles			
Motorized Equipment- low impact		2	0	0
	Portable pump			
	Generator			
	Battery-powered tool			
Motorized Equipment- high impact		3	0	0
	Rock drill			
	Chain saw			
			Total Score	0

TABLE 4: Index of management restrictions on visitor behavior

Category	**Type of Restriction**	**Score**	**Geographic Weight** (1= subarea, 2= entire wilderness)	**Index Score**
Small game hunting during state season (Sharp-tailed and Ruffed Grouse only)	No restrictions	0	2	0
	Permitted but restricted	1		
	Not permitted	2		
Big game hunting during state season (Deer only)	No restrictions	0	2	0
	Permitted but restricted	1		
	Not permitted	2		
Fishing	No restriction	0		
	Permitted but restricted	1		
	Prohibited	2	2	4
Fees	No fees	0	2	0
	Fees charged of selected user type	1		
	Fees charged of all visitors	2		
Permits for general use	No permit or registration	0	2	0
	Voluntary self-registration	1		
	Mandatory; non-limiting registration	2		
	Mandatory; use limited	3		
Human waste	No regulation	0	2	0
	Pack out required	1		
Length of stay	No restrictions	0		
	Length of stay limited	1	2	2
Group size limit	No restrictions	0	2	0
	Group size limits in place	1		
Horseback riding/domesticated animals	No restrictions	0		
	Permitted but restricted	1		
	Prohibited	2	2	4
Camping	No restrictions	0		
	Permit required	1		
	Prohibited	2	2	4
			Total Score =	**14**

TABLE 5: Description of data sources and how the data were gathered

Measure	Priority	Detailed Description of the Data Source(s) and How the Data Were Gathered
Untrammeled Quality		
Number of actions to manage plants	High	Review of Minimum Requirement Analyses, Rhett Johnson's thesis, Refuge biologist
Number of actions to manage animals	Medium	Review of MRA's, personal communication with Kyle Johnson and Mark Ditmer (researchers), Refuge biologist
Number of actions to manage water/soil	High	Review of Water Management Records, CCP, and annual Water Management Plans
Number of actions to manage fire	Medium	Habitat Management Plan, Wilderness Management Plan, Fire Management Plan, Wildland Fire Management Plan, personal communication with Fire Management staff
Number of unauthorized actions taken by agencies, citizen groups, or individuals that influence the community of life inside wilderness.	Low	Refuge manager, Refuge biologist, annual narratives
Natural Quality		
Percent of wilderness dominated by indigenous and/or non-indigenous invasive plant species	High	Unpublished Refuge data
Index of presence and abundance of coniferous bog bird species	Medium	Refuge biologist, The Birds of North America online, Refuge point count data
Index of presence and abundance of open bog bird species	Medium	Refuge biologist, The Birds of North America online, Refuge point count data
Number of active bald eagle nests	Medium	Local data entry by resource specialist (electronic data records provided by Refuge biologist included excel file of nest counts, GIS shapefile and .jpg image of nest locations)
Presence/amount of agricultural and other contaminants in wilderness lakes and/or adjacent ditches	High	Field collection of water samples, lab processing report
Mean winter temperature (Dec-Feb)	Medium	RAWS station data
Mean summer temperature (June-Aug)	Medium	RAWS station data
Total summer precipitation	Medium	RAWS station data
Number of deviations from water levels recommended for Thief Bay Pool and Webster Pool	High	Water Management Records
Undeveloped Quality		
Number of installations for	Medium	Refuge manager, Refuge biologist, annual narratives, Mark Ditmer (bear

research purposes		study researcher), review of MRAs
Miles of dike that bisect the wilderness	High	Refuge biologist, Refuge GIS data
Number of unauthorized, non-recreational physical developments	Low	Refuge manager, Refuge biologist, annual narratives, aerial surveys in the future
Acres of inholdings	Low	Refuge manager, Wilderness Study
Index of authorized motor vehicle, motorized equipment, or mechanical transport usage	Medium	Review of MRAs, Refuge manager, Refuge biologist
Number of two-track trails created by unauthorized vehicle use	Low	Refuge manager, Refuge biologist, aerial surveys in the future
Number of disturbances to cultural resources inside wilderness	Low	Cultural Resources Management Plan, Wilderness Management Plan
Solitude or Primitive and Unconfined Quality		
Percent of wilderness affected by access or travel routes	Medium	Analysis of Refuge GIS data layers
Artificial night sky brightness	Medium	P. Cinzano, F. Falchi (University of Padova), C. D. Elvidge (NOAA National Geophysical Data Center, Boulder).
Number of user-created recreation facilities	Low	Refuge manager, Refuge biologist, aerial surveys in the future
Index of management restrictions on visitor behavior	Medium	Wilderness Management Plan, CCP, Agassiz NWR and State WMA Rules & Regulations

TABLE 6: Effort required per measure for wilderness character monitoring

Quality	Indicator	Measure	Were data gathered from office paper files, computer files, or field work (professional judgment is an option)?	Time you spent locating available data sources (in whole hours)	Time you spent gathering data for each measure (in whole hours)
Untrammeled	Authorized actions	# of actions to manage plants	paper files, professional judgment	3	4
Untrammeled	Authorized actions	# of actions to manage animals	paper files, professional judgment	3	3
Untrammeled	Authorized actions	# of actions to manage water/soil	paper files	3	4
Untrammeled	Authorized actions	# of actions to manage fire	paper files, professional judgment	3	3
Untrammeled	Unauthorized actions	# of unauthorized actions taken by agencies, citizen groups, or individuals that influence the community of life inside wilderness	professional judgment, paper files	1	3
Natural	Plant and animal species	Percent of wilderness dominated by indigenous and/or non-indigenous invasive plant species	Unpublished Refuge data	5	8
Natural	Plant and animal species	Index of presence and abundance of coniferous bog bird species	professional judgment, field, online resources, computer files	2	5
Natural	Plant and animal species	Index of presence and abundance of open bog bird species	professional judgment, field, online resources, computer files	6	5
Natural	Plant and animal species	# of active bald eagle nests	field, computer files	1	2

Natural	Physical resources	Presence/amount of agricultural and other contaminants in wilderness lakes and/or adjacent ditches	field, paper files	2	4
Natural	Biophysical processes	Mean winter temperature (December through February)	RAWS station data (computer files), Excel analysis	2	3
Natural	Biophysical processes	Mean summer temperature (June through August)	RAWS station data (computer files), Excel analysis	1	3
Natural	Biophysical processes	Total summer precipitation (June through August)	RAWS station data (computer files), Excel analysis	1	3
Natural	Biophysical processes	# of deviations from water levels recommended for Thief Bay Pool and Webster Pool	paper files	2	2
Undeveloped	Non-rec structures, installations, and development	# of installations for research purposes	professional judgment, paper files	2	4
Undeveloped	Non-rec structures, installations, and development	Miles of old wilderness dike bisecting the wilderness	professional judgment, GIS files	1	1
Undeveloped	Non-rec structures, installations, and development	# of unauthorized, non-recreational physical developments	professional judgment, paper files	2	2
Undeveloped	Inholdings	Acres of inholdings	professional judgment, paper files	1	2
Undeveloped	Use of motorized or mechanical	Index of authorized motor vehicle, motorized equipment, or mechanical transport usage	professional judgment, paper files	1	5

Undeveloped	Use of motorized or mechanical	Number of two-track trails created by unauthorized vehicle use	professional judgment, paper files	1	2
Undeveloped	Loss of cultural resources	# of disturbances to cultural resources inside wilderness	paper files	1	3
Solitude +	Remoteness from inside	Percent of wilderness affected by access or travel routes	GIS files and analysis	2	2
Solitude +	Remoteness from outside	Artificial night sky brightness	paper	5	1
Solitude +	Facilities that decrease self-reliant recreation	# of user-created recreational facilities	professional judgment	1	2
Solitude +	Mgmt restrictions on visitor behavior	Index of management restrictions on visitor behavior	paper files	2	3